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NOTE ON VARIATION IN *DIACRIA* GRAY, 1847, WITH DESCRIPTIONS OF A SPECIES NEW TO SCIENCE, *DIACRIA RAMPALI* NOV. SPEC., AND A FORMA NEW TO SCIENCE, *DIACRIA TRISPINOSA* FORMA *ATLANTICA* NOV. FORMA

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ABSTRACT

Variation of shell shape and colour pattern in the *Diacria trispinosa* group consisting of 3 taxa, *D. rampali* n. sp., *D. trispinosa* f. *trispinosa* and *D. trispinosa* f. *atlantica* n.f., have been studied. *D. trispinosa* is distinct in colour pattern and has a shell shape somewhat different from that of *D. rampali.* The difference in shell shape consists chiefly of a higher position of the lateral spines; this position is indicated by the l/m ratio. Discriminant analysis has been used to separate *D. rampali* and *D. trispinosa.* Specimens from the Philippine area can be well discriminated but specimens from the Atlantic Ocean can only be separated if one also uses differences in colour pattern. The colour patterns of *D. rampali* and *D. trispinosa* are distinct and their development is different. In the Atlantic north of 30°N *D. trispinosa* becomes larger with higher latitudes, due to adaptation in favour of the floating capacity. The teleoconch becomes fully coloured. These North Atlantic populations have been described as *D. trispinosa* f. *atlantica.* Specimens of *D. trispinosa* f. *trispinosa,* living at higher latitudes do not show enlargement of the teleoconch. *D. trispinosa* f. *atlantica* is restricted in distribution to the North Atlantic Ocean. *D. major* has been found in the North Atlantic and the Pacific Ocean. In the material studied, no *D. major* was found in the Indian, nor in the South Atlantic Ocean. *D. trispinosa* f. *trispinosa* has been collected in all oceans. *D. rampali* has been found in the Atlantic and the Pacific Oceans.

INTRODUCTION

The variability in *Diacria* has been discussed by various authors (Boas, 1886; Van der Spoel, 1970; Rampal, 1975; etc.). *Diacria trispinosa* (De Blainville, 1821) was considered a monotypic species, although its variation is great. The above-mentioned authors considered this variation as only ecophenotypic. In this paper it is shown that *D. trispinosa* can be split up into 3 taxonomic groups, mainly based on differences in colour pattern, correlated with differences in shell shape. One species and one forma, both new to science, has been distinguished besides *D. trispinosa* s.s.

MATERIAL AND METHODS

Alcohol-preserved material from the Atlantic Ocean and from West of New Guinea and Recent sediment material from the Atlantic and Indo-Pacific Oceans has been studied. Special attention was given to the Caribbean Sea, the North Atlantic Ocean and the Philippine area. This material has been collected mainly by the United States Bureau of Fisheries and the Dana expeditions. Eleven measurements of the shell have been taken, of which B, D, E, I, L, M and O (see Fig. 1) are accurate up to 0.07 mm and A, G, J and K are accurate up to 0.02 mm. Besides, attention was paid to the colour pattern. Material collected by the Dana expeditions in the South Atlantic, the Indian and the South Pacific Oceans has not been incorporated in the computer programs. Age discrimination was possible by means of histological examination of the developmental stage of soft parts. Discriminant analysis has been made to distinguish the groups according to size differences apart from colour pattern variation. This multiple discriminant analysis was performed using the SPSS subprogram DISCRIM (Nie et al., 1975).

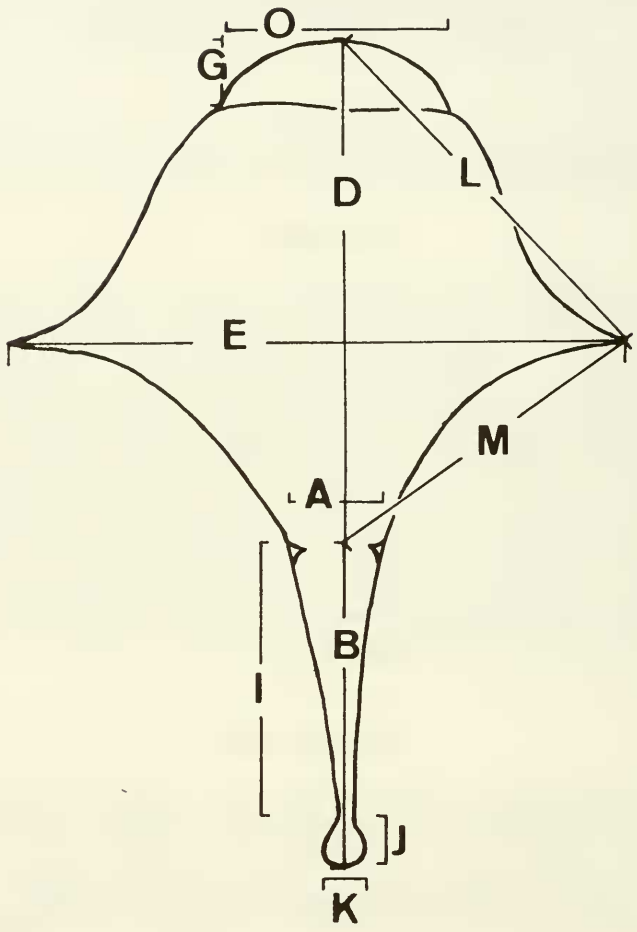

FIG. 1. Measurements taken from the shell:

		accuracy (in mm)
A	width at the membrane (lowest part of the teleoconch)	(0.02)
B	length of the posterior spine	(0.07)
D	length of the teleoconch	(0.07)
E	maximal width (between lateral spines)	(0.07)
G	height of the shell aperture	(0.02)
I	length of protoconch II	(0.07)
J	length of protoconch I	(0.02)
K	width of protoconch I	(0.02)
L	length from the lateral spine to the dorsal rim of the shell aperture	(0.07)
M	length from the lateral spine to the membrane	(0.07)
O	width of the shell aperture	(0.07)

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RESULTS

In the present study variation of the colour pattern and size is compared. The colour pattern variation shows 2 types correlating with 2 types of shell shape. The development of the colour pattern has been studied in a series of specimens of different ages (see Fig. 2). The studied specimens, preserved in alcohol, have been collected by the Dana expedition 1922 at 16°06′ N 76°02′ W. The 2 types of colour pattern proved to be distinct throughout the developmental stages of the animals. In many samples, from plankton as well as from sediment, representatives of both types have been found. The 2 groups differing in colour pattern are sympatric in the Atlantic Ocean and the Philippine area. The colour patterns of the sympatric groups are distinct and therefore these groups will be considered different species: *D. rampali* nov. spec. and *D. trispinosa.*

Size variation is correlated with variation in coloration and distribution. A group of populations of *D. trispinosa* in the North Atlantic Ocean shows large, dark shells. Intermediates between these populations and more southern populations have been found. In the northern populations shell size increases with higher latitudes. Therefore the northern populations are considered to represent a forma new to science: *D. trispinosa* forma *atlantica* nov. forma.

Diacria rampali nov. spec. (Fig. 3)

The species name is given in honour of Dr. J. Rampal, who was the first to pay full attention to the variation of *D. trispinosa* and its related forms.

Holotype: adult specimen in Universitetets Zoologisk Museum, Copenhagen.

Paratypes: 1 adult specimen, 2 transitionals and 2 minutes in Universitetets Zoologisk Museum, Copenhagen, and 2 adults and 6 transitionals in Zoological Museum, Amsterdam.

Type locality: 16°06′ N 76°02′ W; depth 300 meter wire, Dana expeditions, station 1215 IV; 27-1-1922.

This species may be identical with *Hyalaea aculeata* d'Orbigny, 1846: 687, pl. 7 fig. 1-5. The colour pattern of *Hyalaea aculeata* is the same as that of *D. rampali* but shell shapes are different.

Hyalaea trispinosa d'Orbigny, 1836: 106.

Diacria trispinosa Adams, 1853: I, 52 pl. 6 fig. 2a; Adams, 1859: 45; (in part) Vayssière, 1915: 58, pl. 1 fig. 14.

Description. Rather small species; teleoconch slender posterior to the lateral spines, caudal spine long, shell aperture small, rim of shell-aperture and the middle of dorsal ribs brown. The colour of the ventral lip is connected with a spot on the teleoconch anterior to the lateral spines. Lateral spines are white and sometimes lateral ribs are very light brownish. When a specimen grows older, the colour becomes more intense. Minute stages and often transitional stages lack the brown spot on the teleoconch. In adults the anterior half of the teleoconch sometimes becomes fully coloured. Table 1 shows the measurements of the holotype.

TABLE 1. Measurements (in mm) of the holotype of *D. rampali.*

A	0.77	J	0.24
B	3.88	K	0.20
D	5.98	L	4.49
E	7.48	M	4.88
G	0.59	O	2.73
I	3.64	L/M	0.92

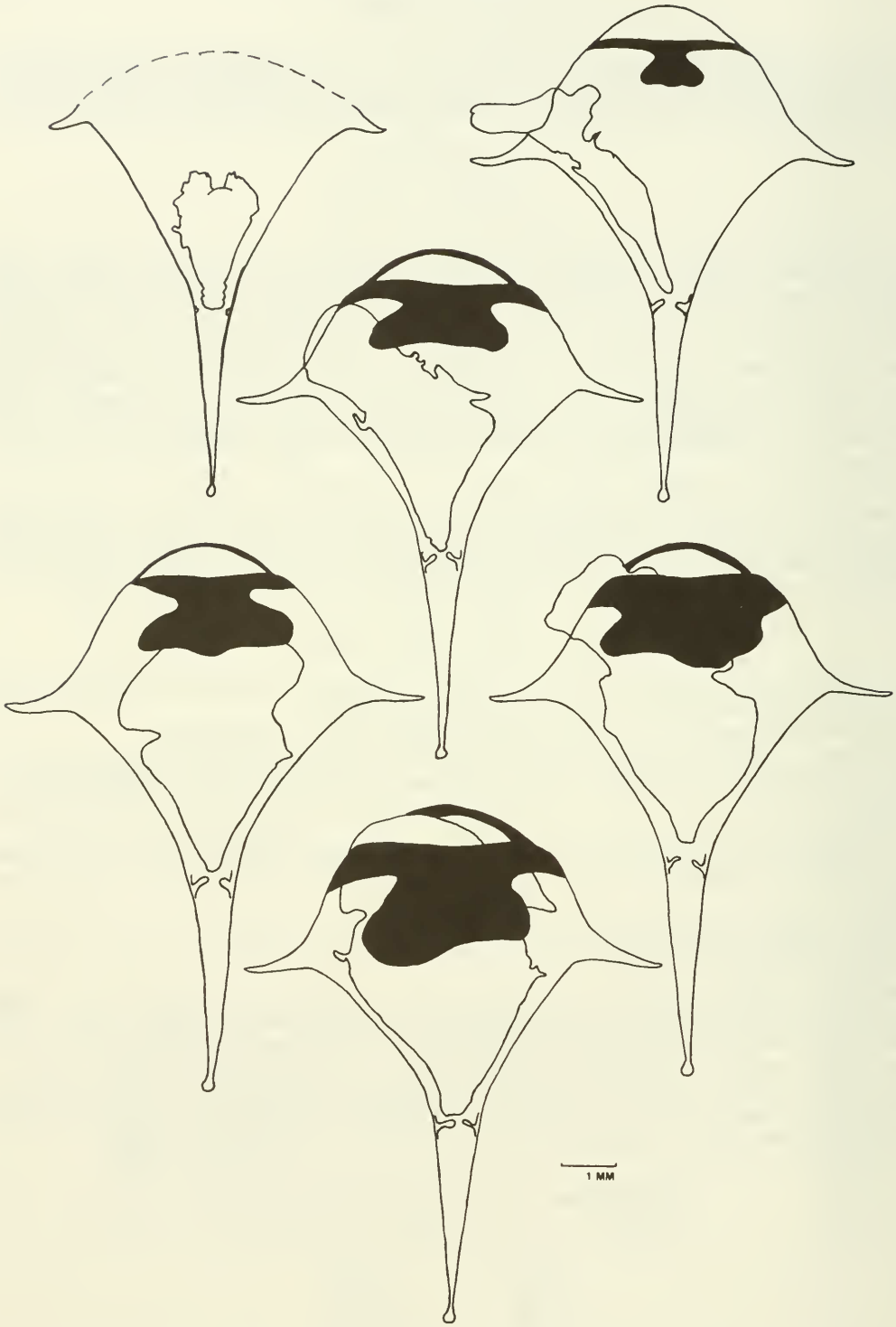
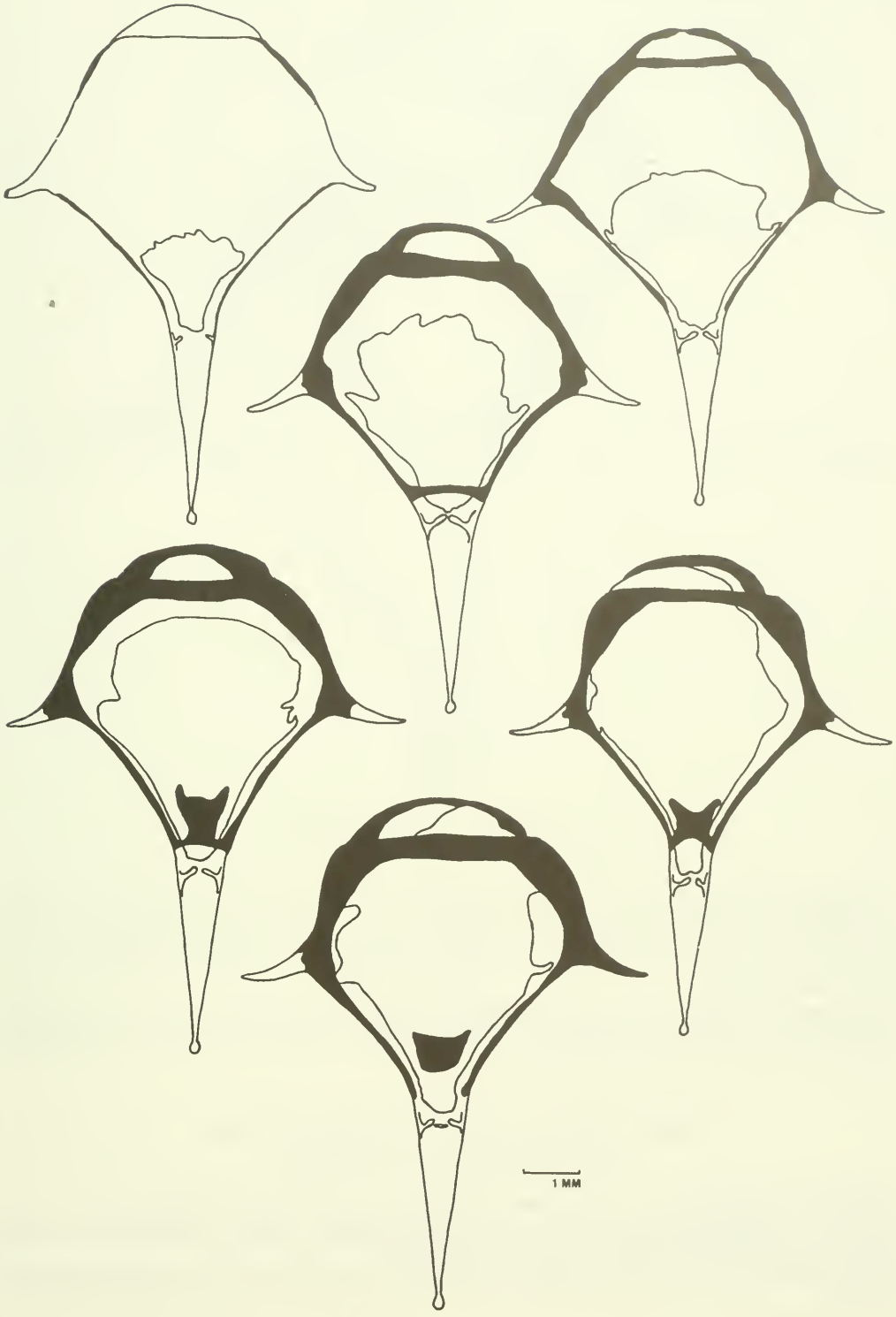


FIG. 2. Colour pattern development in *D. trispinosa* f. *trispinosa* (right) and in *D. rampali* (holotype and paratypes) (left).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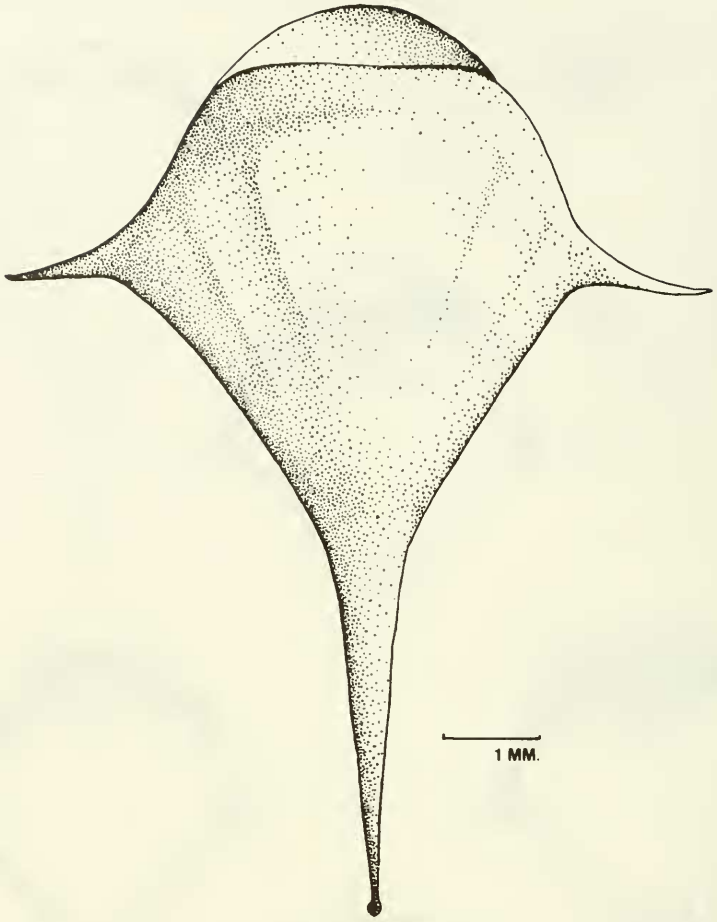

FIG. 3. Holotype of *D. rampali* nov. spec.

Compared to *D. trispinosa* the dorsal aperture rim is less curved, the caudal spine is longer, the vaulting of the teleoconch is slightly less, the lateral growth of the ventral aperture rim in the adult stage is less pronounced. The lateral ribs are white instead of brown as in *D. trispinosa,* and *D. rampali* lacks the light brown spot present in the adult stage of *D. trispinosa* near the caudal spine.

Compared to *Diacria major* (Boas, 1886) the teleoconch is smaller and slender, the lateral spines are less curved, the caudal spine is proportionally longer. The colour of *D. major* is restricted to the rims of the shell aperture.

Diacria trispinosa (ms Lesueur) (De Blainville, 1821)
forma **atlantica** nov. forma (Fig. 4)

Holotype: adult specimen in Universitetets Zoologisk Museum, Copenhagen.

Paratype: 100 adult specimens in Universitetets Zoologisk Museum, Copenhagen, and 709 adults and 1 minute in Zoological Museum, Amsterdam.

Type locality: 39°21'N 21°51'W; depth 300 meter wire, Dana expeditions, station 1380 IV; 19-6-1922.

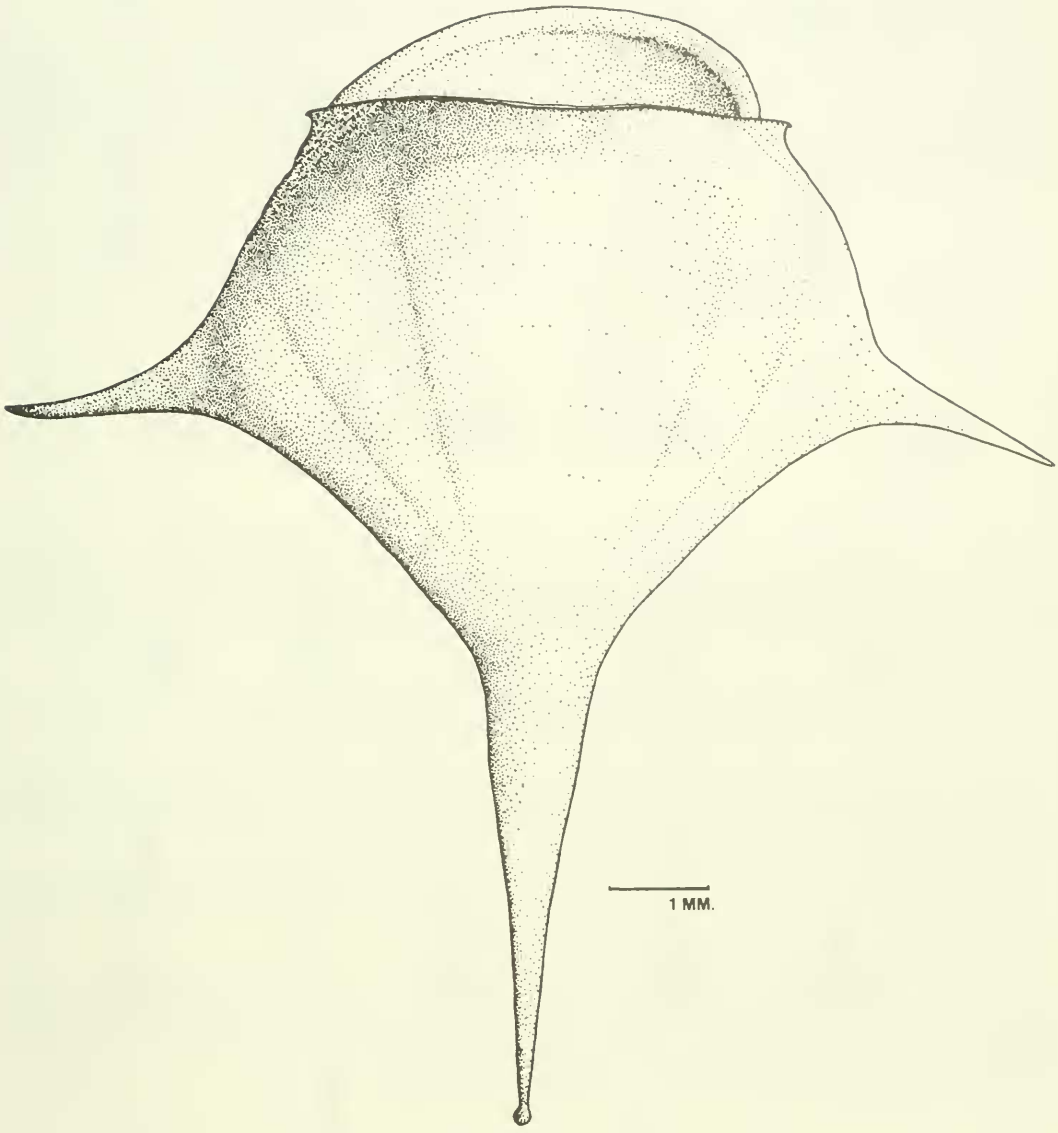

FIG. 4. Holotype of *D. trispinosa* f. *atlantica* nov. forma.

Hyalaea trispinosa. Quoy & Gaimard, 1832: 378, (1833) pl. 27 fig. 17-19; (in part) Souleyet, 1852a: 45; (in part) Souleyet, 1852b: 161.

Diacria trispinosa (in part). Gray, 1847: 203; (in part) Vayssière, 1915: 58, pl. 1 fig. 11; Tesch, 1907: 195.

Diacria depressa ? Gray, 1850: 11.

Diacria trispinosa var. *minor* (in part) Boas, 1886: 95, 210, pl. 1 fig. 3, pl. 2 fig. 14.

Description. Shell large, up to 9 mm teleoconch length. Lateral spines rather straight. Caudal spine proportionally short, shell aperture wide. The holotype is darkly coloured at the anterior part of the teleoconch; the posterior part is light brown and the spines are white. The position of the membrane is low in the caudal spine, therefore the teleoconch is long and the caudal spine short. Measurements of the holotype are given in Table 2.

TABLE 2. Measurements (in mm) of the holotype of *D. trispinosa* f. *atlantica*.

A	0.85	J	0.27
B	3.29	K	0.21
D	7.94	L	6.92
E	10.52	M	6.15
G	0.93	O	4.22
I	3.02	L/M	1.12

Shells of the northern populations of this taxon are darker and the teleoconch is completely brown with exception of the spines. In the southwestern populations only the ribs of the shell and the aperture rim are coloured. Intermediates between these colour patterns are abundant. The length of the teleoconch of this forma varies also with latitude.

Diacria trispinosa (ms Lesueur) (De Blainville, 1821)
forma *trispinosa* (ms Lesueur) (De Blainville, 1821)

Hyalaea trispinosa (ms Lesueur) (in part) De Blainville, 1821a: 82; De Blainville 1821b: 97; d'Orbigny, 1836: 106; (in part) Souleyet, 1852a: 45, pl. 3 fig. 1-7; (in part Souleyet, 1852b: 161, pl. 6 fig. 1-6.

Hyalaea mucronata (non d'Orbigny, 1836). Quoy & Gaimard, 1827: 231, pl. 8b fig. 1-2.

Diacria trispinosa (in part). Gray, 1847: 203; (in part) Gray, 1850: 10; Chenu, 1859: 109, fig. 4, 65-466.

Diacria trispinosa var. *minor* (in part) Boas, 1886: 95, 210.

Description. Teleoconch length about 6 mm. The teleoconch length does not show variation with latitude. The colour pattern of *D. trispinosa* f. *trispinosa* is restricted to the ribs of the shell and the aperture rims, but sometimes adult specimens get a brown spot on the teleoconch posterior to the lateral spines, on the ventral side. The aperture is smaller and the posterior spine proportionally longer than in *D. trispinosa* f. *atlantica*.

REMARKS ON VARIATION

The measurements A, D, E, G, L and M (see Fig. 1) are used to study teleoconch variation. In the histograms (Fig. 5) the size of the different taxa may be compared. The ratio L/M (= distance from lateral spine to dorsal aperture rim/distance from lateral spine to membrane) is an indicator for the position and curving of the lateral spines. For *D. rampali* and *D. trispinosa* f. *trispinosa* from the Atlantic Ocean this ratio differs slightly. Most Atlantic and all Philippine specimens of *D. rampali* have a lower L/M ratio; consequently this means a higher position of lateral spines compared to *D. trispinosa* f. *trispinosa*. Atlantic specimens of *D. rampali* have

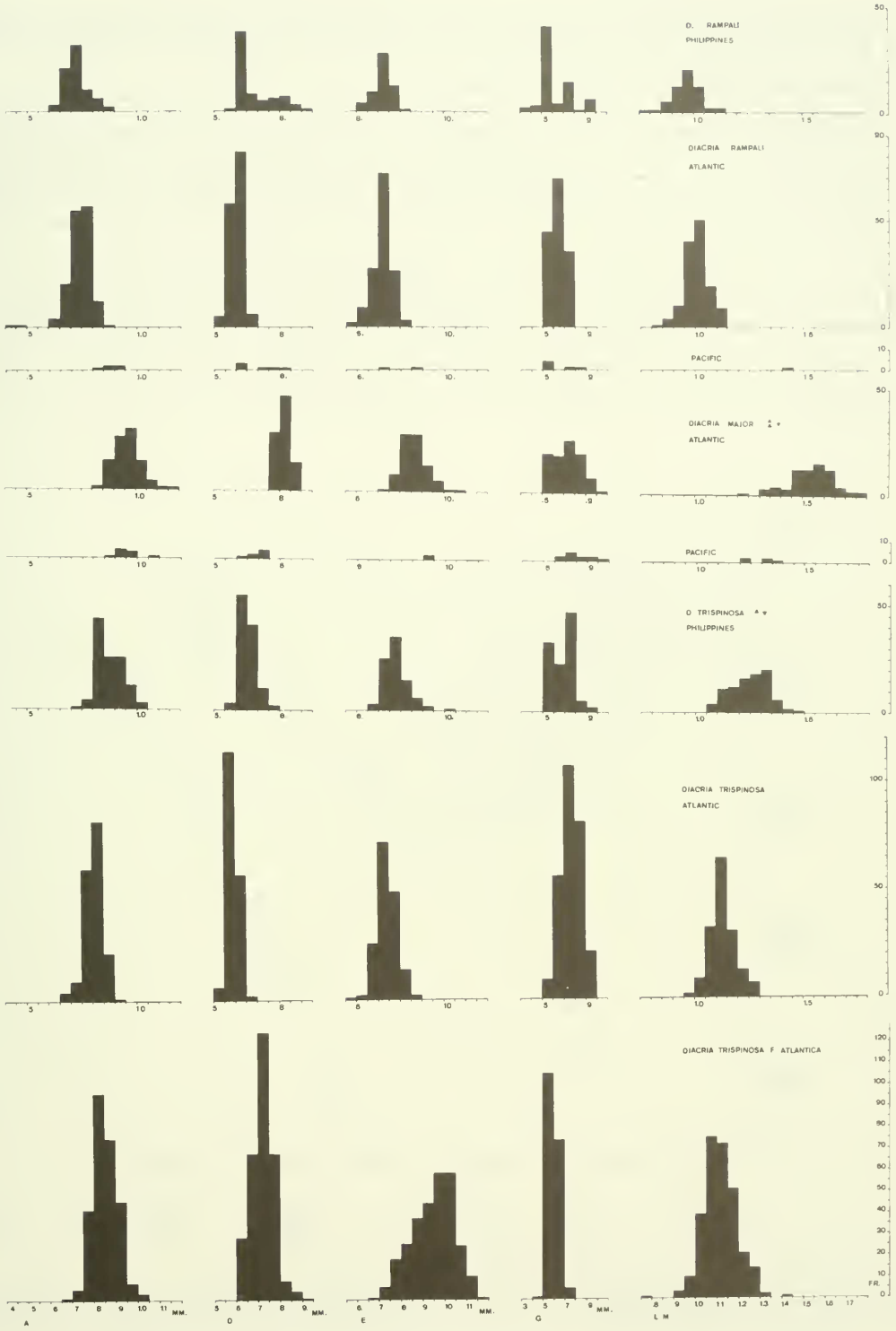

FIG. 5. Histograms of parameters of shell shape and size of different taxa in different oceans.

almost the same L/M ratio as *D. trispinosa* f. *atlantica*, but the latter is much bigger, as is shown by the teleoconch length (D) and the maximal width (E). The length of the teleoconch in Atlantic specimens of *D. trispinosa* f. *trispinosa* is slightly less than that in *D. rampali*; in the Philippine area the difference is just the reverse.

The length of the teleoconch of *D. trispinosa* f. *atlantica* becomes larger at higher latitudes. In Fig. 6 mean and standard deviation of data are plotted against latitude. According to Van der Spoel (1970a) this variation is due to adaptation to colder and less saline waters to enlarge the floating capacity. Only the mean of the samples from the Sargasso Sea, North of the Azores (arrows), does not fit. This is probably due to isolation of these water masses. In Fig. 6 the teleoconch length variation of *D. major* sampled in the Atlantic Ocean is also plotted, which shows a comparable phenomenon.

Discriminant analyses have been made for 4 groups, based on colour pattern: the taxa *D. rampali, D. major, D. trispinosa* f. *trispinosa, D. trispinosa* f. *atlantica.* Shell shape differences of these groups have been studied. The analyses were carried out with 3 parameters of the shell: A = width of the shell at the level of the membrane; L = distance of the lateral spine and the dorsal aperture rim; M = distance between the lateral spine and the membrane. These parameters have been chosen because they discriminate well and their correlation is limited (Table 3).

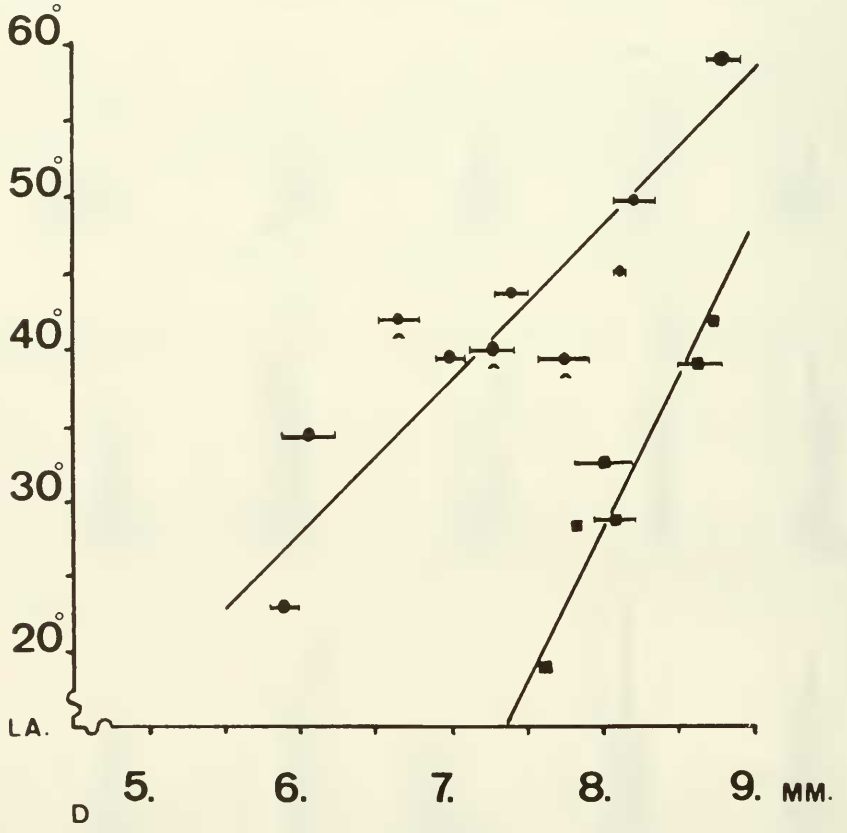

FIG. 6. Mean and standard deviation of samples of *D. trispinosa* f. *atlantica* (black dots) and of *D. major* (black squares), plotted against latitude.

TABLE 3. Correlation matrix of the parameters A, L and M in the taxa *D. rampali, D. major, D. trispinosa* f. *trispinosa, D. trispinosa* f. *atlantica.*

	D. rampali		*D. major*		*D. trispinosa* f. *trispinosa*		*D. trispinosa* f. *atlantica*	
	L	M	L	M	L	M	L	M
A	.19	.01	.37	.47	.01	.03	.24	.16
L	x	.48	x	.55	x	.44	x	.61

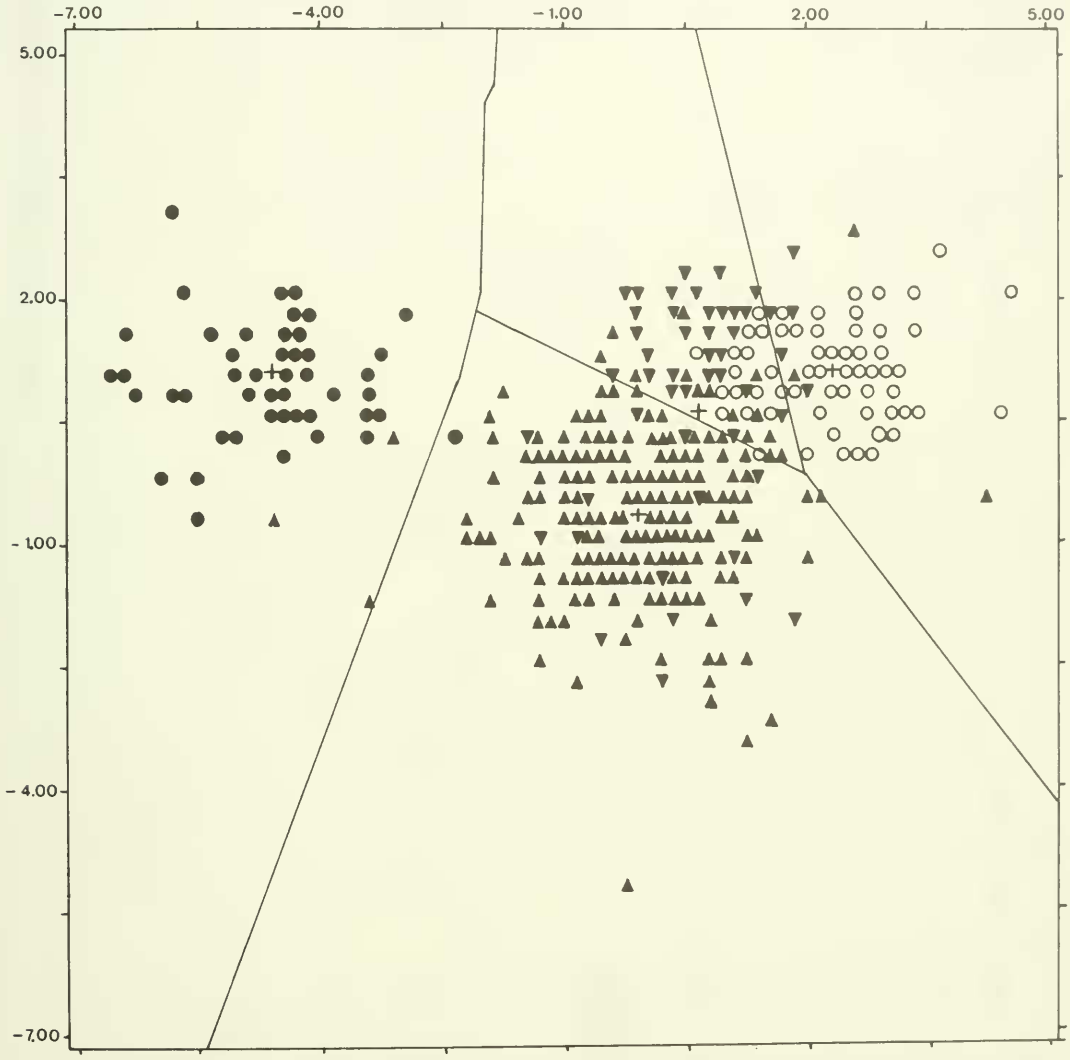

FIG. 7. 'Plot of single cases' of discriminant analysis for 4 groups: *D. rampali* (circles), *D. major* (black dots), *D. trispinosa* f. *trispinosa* (triangles downward), *D. trispinosa* f. *atlantica* (triangles upward), of which the cases or specimens were sampled in the Atlantic Ocean.

In Fig. 7 a discriminant analysis of specimens sampled from the Atlantic Ocean is given. Fig. 7 shows that *D. major* is easily recognised using the above mentioned parameters. The ranges of variability of *D. rampali* and *D. trispinosa* f. *trispinosa* overlap but the centroids are distinct. With this method it was possible to separate up to 81% of Atlantic specimens of *D. rampali* from *D. trispinosa* f. *trispinosa. D. trispinosa* f. *atlantica* and *D. rampali* do not overlap. Separation between *D. trispinosa* f. *trispinosa* and *D. trispinosa* f. *atlantica* is distinct for 89% of the specimens. In relation to these data one has to consider that the colour pattern of *D. rampali* is distinct from that of *D. trispinosa,* and that there are intermediates in colour pattern between *D. trispinosa* f. *trispinosa* and *D. trispinosa* f. *atlantica.* In Fig. 8 discriminant analysis of specimens sampled from the Philippine area is given. It shows that there is no overlapping of *D. rampali* and *D. trispinosa* f. *trispinosa* when parameters A, L and M are used for these specimens. Separation of *D. rampali* and *D. trispinosa* f. *trispinosa* only based on colour pattern gives the same groups as the separation based on shell shape.

Results drawn from the discriminant analyses are identical with the conclusions from the histograms.

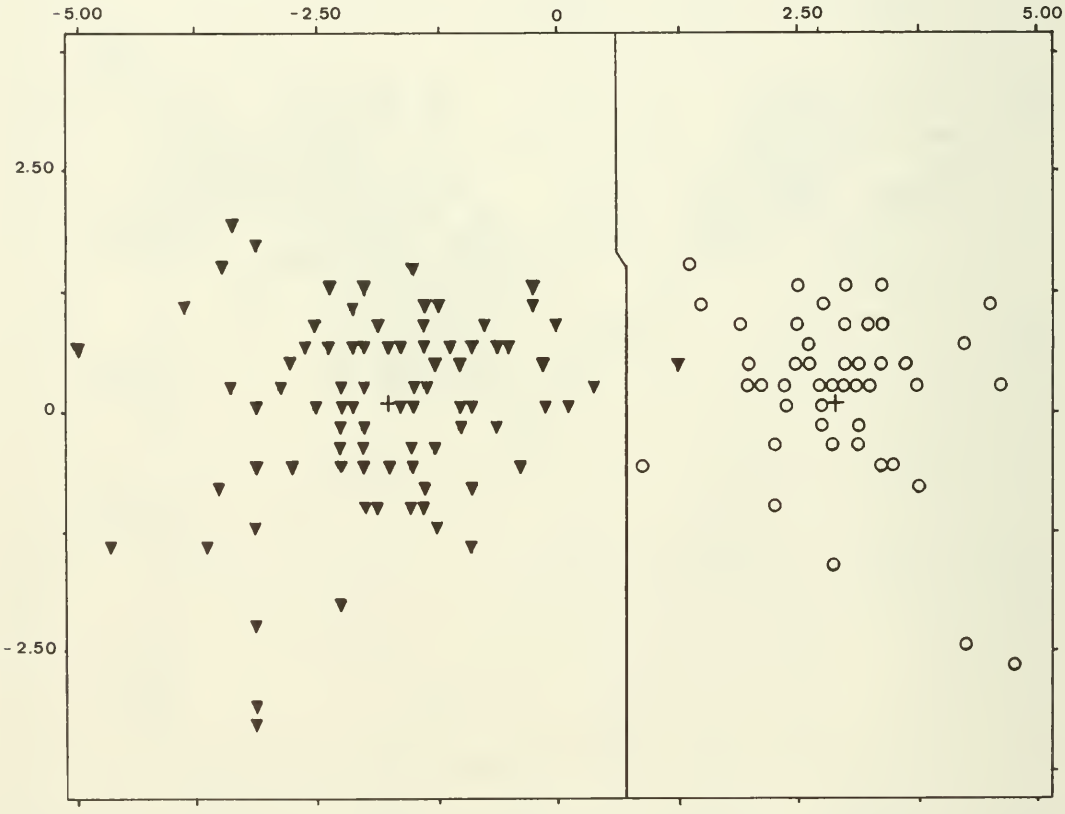

FIG. 8. 'Plot of single cases' of discriminant analysis for 2 groups: *D. rampali* (circles) and *D. trispinosa* f. *trispinosa* (triangles); cases or specimens were sampled in the Philippine area.

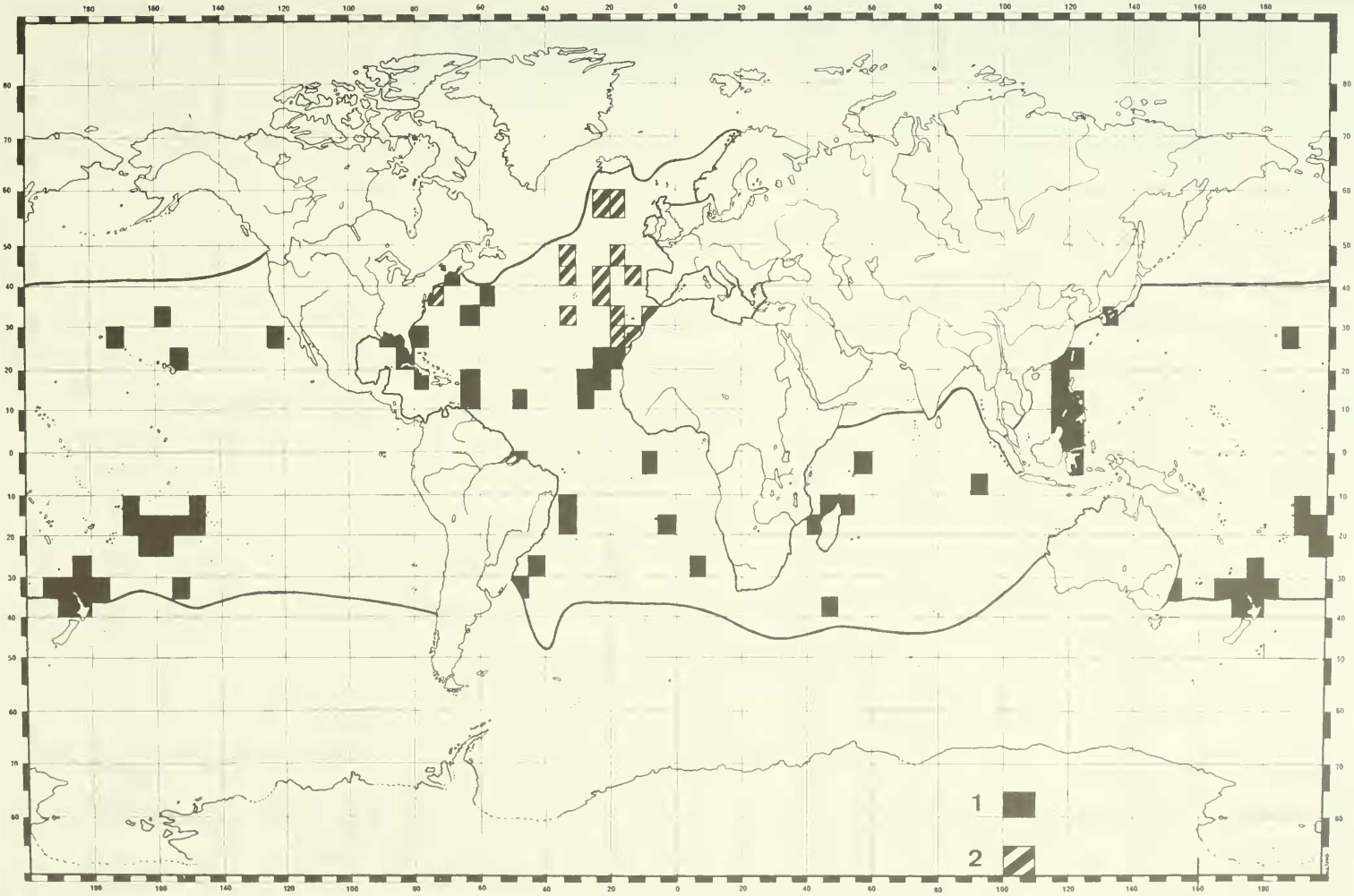

FIG. 9. Map of the distribution of *D. trispinosa* f. *trispinosa* (1) and of *D. trispinosa* f. *atlantica* (2). The boundary of the distribution of *D. trispinosa* is given with a single line. The arrow indicates the spot where *D. trispinosa* f. *trispinosa* has only been found in sediment and not as Recent material.

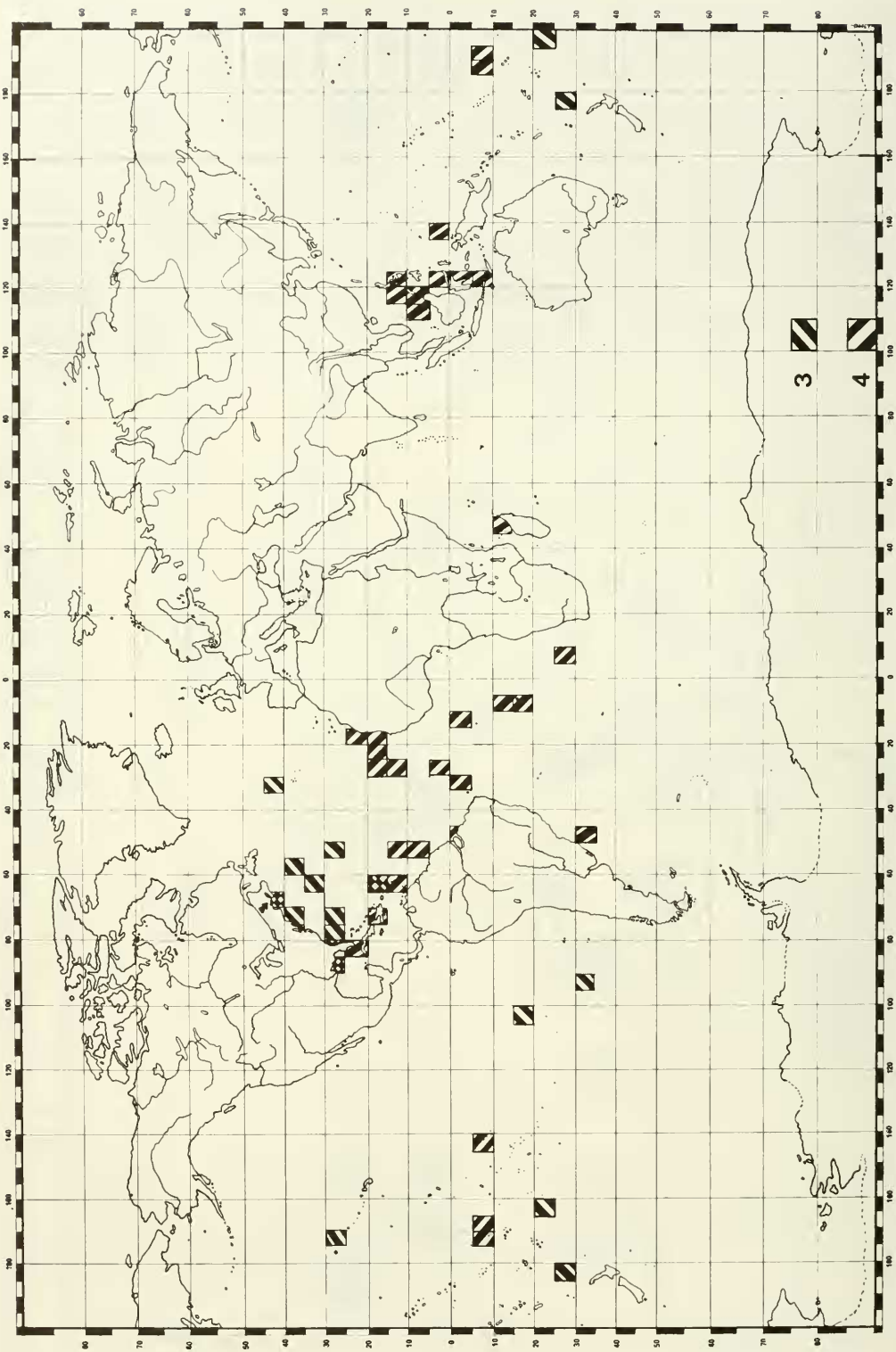

FIG. 10. Map of the distribution of *D. major* (3) and *D. rampali* (4). The arrow indicates the spot where *D. rampali* has only been found in sediment and not as Recent material.

DISTRIBUTION

The localities of the material studied, measured as well as unmeasured specimens, are represented on Figs. 9 and 10. Due to lack of material the North Pacific Ocean has hardly been investigated.

The distribution of *D. trispinosa* f. *atlantica* is restricted to the North Atlantic Ocean, between 60° N and 30-25° N. At the southern border intermediates with *D. trispinosa* f. *trispinosa* occur.

D. trispinosa f. *trispinosa* has been found in all oceans down to 35° S. It occurs up to 35° N in the Atlantic and, according to Van der Spoel (1967), up to 40° N in the Pacific Ocean. In most of the studied areas *D. trispinosa* f. *trispinosa* is sympatric with *D. rampali.*

D. rampali has been collected in the Atlantic Ocean between 30° N and 35° S. In the Pacific it has been sampled between 15° N (Philippine area) and 10° S. It is possible that the distribution of *D. rampali* in the Pacific Ocean is wider than given here.

D. major has been collected in the North Atlantic Ocean up to 30° N and in the Pacific Ocean down to 35° S. Among the material investigated no *D. major* has been found in the South Atlantic nor in the Indian Ocean.

Near the coast off Georgia, in sediment material, *D. trispinosa* f. *trispinosa* and *D. rampali* have been found. On the maps (Figs. 9 and 10) this is indicated by an arrow. Neither *D. rampali* nor *D. trispinosa* f. *trispinosa* have been collected recently in the same areas, though they have been well explored by the Deep Dumpsite Project. So either the 2 taxa are regressing in distribution or the waters near Georgia had a higher temperature in the recent geological past. The last hypothesis contradicts other paleontological and geological evidence. Therefore it is postulated here that *D. rampali* and *D. trispinosa* f. *trispinosa* have had a larger distribution in the Atlantic Ocean.

LITERATURE CITED

ADAMS, A., 1859, On the synonyms and habitats of *Cavolina, Diacria* and *Pleuropus. Annals and Magazine of Natural History* (3)3: 44-46.

ADAMS, H. & ADAMS, A., 1853, *The genera of Recent Mollusca,* 1 and 3. John van Voorst, London, 256 p.

BLAINVILLE, M. H. D. DE, 1821a, (ms Lesueur), *Dictionnaire des sciences naturelles 22.* Paris & Strasbourg, 570 p.

BLAINVILLE, M. H. D. DE, 1821b, Mémoire sur le genre Hyale. *Journal de Physique, de Chimie et d'Histoire Naturelle,* 93: 81-97.

BOAS, J. E. V., 1886, Spolia Atlantica. Bidrag til Pteropodernes. Morfologi og Systematik samt til kundskaben om deres geografiske udbredelse. *Kongelige Danske Videnskabernes Selskabs Skrifter, 6. Raekke, Naturvidenskabelig og Mathematisk Afdeling,* 4(1): 1-231.

CHENU, J. C., 1859, *Manuel de Conchyliologie et de Paléontologie conchyliologique.* Victor Masson, Paris, 508 p.

GRAY, J. E., 1847, A list of the genera of Recent Mollusca, their synonyma and types. *Proceedings of the Zoological Society of London,* (1847) 15: 129-219.

GRAY, J. E., 1850, *Catalogue of the Mollusca in the collection of the British Museum II Pteropoda.* E. Newman, London, 45 p.

NIE, N. H., HADLAI HULL, C., JENKINS, J. G., STEINBRENNER, K. & BENT, D. H., 1975, *SPSS: Statistical Package for Social Sciences.* Modified version 65, 26 May 1977. Vogelback Computing Center, Northwestern University. McGraw Hill Book Company, New York.

D'ORBIGNY, A., 1836, *Voyage dans l'Amérique méridionale exécuté pendant les années 1826-1833, Mollusques,* 5(3): 49-184. Bertrand, Paris.

D'ORBIGNY, A., 1846, *Voyage dans l'Amérique méridionale exécuté pendant les années 1826-1833, Mollusques,* 5(3), Atlas pls. 1-85. Bertrand, Paris.

QUOY, J. R. C. & GAIMARD, J., 1827, Observations zoologiques faites à bord de "l'Astrolabe" en mai 1826, dans le détroit de Gibraltar: description des genres Biphore, Carinaire, Hyale, Flèche, Cleodore, Anatife et Briarée. *Annales des Sciences Naturelles,* 10: 225-239 + Atlas.

QUOY, J. R. C. & GAIMARD, J., 1832, *Voyage de découvertes de* "l'Astrolabe," Zoologie, 2. Tastu, Paris, 686 p. + Atlas (1833).

RAMPAL, J., 1975, *Les Thécosomes (Mollusques pélagiques). Systématique et évolution. Ecologie et biogéographie méditerranéennes.* Thèse Doctorat d'Etat, Université de Provence, Marseille, CNRS AO. 11932, 485 p.

SOULEYET, F. L. A., 1852a, In: Rang, S. & Souleyet, F. L. A., *Histoire naturelle de mollusques ptéropodes. Monographie comprenant la description de toutes les espèces*: 1-86. J. B. Baillière, Paris.

SOULEYET, F. L. A., 1852b, In: Eydoux, J. F. T. & Souleyet, F. L. A., *Voyage autour du monde exécuté pendant les années 1836 et 1837 sur la corvette "La Bonite." Zoologie,* 2. Bertrand, Paris, 664 p. + Atlas.

SOWERBY, G. B., Jr., 1859, *Illustrated index of British shells. British supplement to Thesaurus Conchyliorum*: 1-15. Simpkin, Marshall & Co., London.

SPOEL, S. VAN DER, 1967, *Euthecosomata, a group with remarkable developmental stages.* Noorduyn & Zn, Gorinchen, 375 p.

SPOEL, S. VAN DER, 1970, Morphometric data on Cavoliniidae with notes on a new form of *Cuvierina columnella* (Rang, 1827) (Gastropoda, Pteropoda). *Basteria,* 34:103-151.

TESCH, J. J., 1907, Pteropoda of the Leyden Museum. *Notes of the Leyden Museum,* 29: 181-203.

VAYSSIERE, A., 1915, Mollusques Euptéropodes (Ptéropodes thécosomes) provenant des campagnes des yachts "Hirondelle" et "Princesse Alice" (1885-1913). *Résultats des Campagnes Scientifiques accomplies sur son yacht par Albert Ier, Prince Souverain de Monaco,* 47: 3-226.